CLEAN VERSION OF ALL PENDING CLAIMS

1. A multi-phase bipolar brushless D.C. motor comprising:

a stator constituted by M phases, each phase having a plurality of windings connected in parallel and further connected independently of the winding connection of the other phases;

a rotor shaft rotatably coupled to said stator and having N embedded permanent magnet poles which concentrate flux between opposing faces of like polarity;

a commutation encoder fixed at one end of the rotor shaft comprising a circular plate and an annular ring defining at least one light shielding portion which functions as a non-sensing area, and at least one light detecting portion having opposite vertical edges which functions as a sensing area;

photo-sensors coupled operatively with the commutation encoder and being constituted so that two photo-transistors are provided with respect to each phase, each of the photo-transistors in the M phases being arranged, in turn, and one by one at intervals of predetermined shaft angle so as to produce a positive pulse when registered with the sensing area of the commutation encoder;

an electronic commutator constituted in such a manner that four power transistors are connected across the windings of each phase of the stator, two of the four power transistors of each phase being connected to one of the photo-transistors so that each phase is provided with two photo-transistors in order to perform the determination of the current direction according to the positive pulse of the photo-transistors, thereby flowing the alternating current through the windings to drive the motor; and

an electric power source connected in parallel to each phase of said electronic commutator;

wherein the width of the light detecting potion is determined by the following formula:

2π/ the number of poles x (the number of phases x K/the number of phases), wherein K is the commutation coefficient;

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the number of the light detecting portions is determined by the following formula:

(the number of poles)/2; and

the interval between each of the photo-transistors is determined by the following formula:

$2\pi/$ (the number of poles) x 1/(the number of phases);

whereby the motor can be composed of one selected from a group consisting of 2-phase with 1-x-exciting, 3-phase with 2-y-exciting, 4-phase with 3-z-exciting . . . n-phase with (n-1-j)-exciting, where x, y, z and j are fractional commutation coefficients, thereby raising the efficiency, power, and speed of the motor.

3. The motor of claim 1, wherein the photo-sensor position of every other photo-sensor in the rotational sequence is moved rotationally to another pole of the same polarity at the same location in that pole as the original pole according to the formula: $4/\pi$(the number of poles), when the motor has insufficient area to properly position all of the photo-sensors.

4. The motor of claim 1, wherein the photo-sensors are arranged in a form of advanced commutation by a given angle in the direction adverse to the rotational direction of the commutation encoder from theoretical position to improve the performance of the motor.

5. The motor of claim 1, wherein the photo-sensor is coupled operatively with the commutation encoder in such a manner that, as occasion demands, the width between the light sensing portion can be adjusted in order to slightly change the width of the sensing area of the light detecting portion in order to modulate the exciting width of the windings and produce a bipolar partial square waveform.

6. The motor of claim 1, wherein the photo-sensor includes a set of photo-transistors for use in a reverse rotation which set is provided in symmetric position separated from the two photo-transistors for use in forward rotation.

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7. The motor of claim 1, wherein the N permanent magnet poles are formed by embedded magnets.

8. The motor of claim 1, wherein the commutation encoder is fixed to the rotor shaft outside of the motor and is of cylindrical configuration.

9. A multi-phase bipolar brushless D.C. motor, comprising:

a stator defining M phases, having a plurality of windings connected in parallel and independently of the winding connection of the other phases;

a rotor shaft rotatably coupled to said stator and having N permanent magnet poles for concentrating flux between opposing faces of like polarity;

a commutation encoder at one end of the rotor shaft defining at least one light shielding portion which functions as a non-sensing area, and at least one light detecting portion which functions as a sensing area;

photo-sensors corresponding to each phase and coupled operatively with the commutation encoder, the photo-transistors being arranged so as to produce a positive pulse when registered with the sensing area of the commutation encoder;

an electronic commutator including power transistors connected across the windings of each phase of the stator and to one of the photo-transistors so that each phase is provided with a plurality of photo-transistors in order to perform the determination of the current direction, thereby flowing the alternating current through the windings to drive the motor; and

an electric power source connected in parallel to each phase of said electronic commutator;

wherein the width of the light detecting potion is determined by the following formula:

$2\pi/$ the number of poles x (the number of phases x K/the number of phases), wherein K is the commutation coefficient;

the number of the light detecting portions is determined by the following formula:

(the number of poles)/2; and

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the interval between each of the photo-transistors is determined by the following formula:

$2\pi/$ (the number of poles) x 1/(the number of phases);

whereby the motor is selected from a group consisting of 2-phase with 1-x-exciting, 3-phase with 2-y-exciting, 4-phase with 3-z-exciting. . . n-phase with (n-1-j)-exciting, where x, y, z and j are fractional commutation coefficients, thereby raising the efficiency, power, and speed of the motor.

11. The motor of claim 9, wherein the photo-sensor position of every other photo-sensor in the rotational sequence is moved rotationally to another pole of the same polarity at the same location in that pole as the original pole according to the formula: $4\pi/$(the number of poles), when the motor has insufficient area to properly position all of the photo-sensors.

12. The motor of claim 9, wherein the photo-sensors are arranged in a form of advanced commutation by a given angle in the direction adverse to the rotational direction of the commutation encoder from theoretical position to improve the performance of the motor.

13. The motor of claim 9, wherein the photo-sensor is coupled operatively with the commutation encoder in such a manner that, as occasion demands, the width between the light sensing portion can be adjusted in order to slightly change the width of the sensing area of the light detecting portion in order to modulate the exciting width of the windings and produce a bipolar partial square waveform.

14. The motor of claim 9, wherein the photo-sensor includes a set of photo-transistors for use in a reverse rotation which set is provided in symmetric position separated from the two photo-transistors for use in forward rotation.

15. The motor of claim 9, wherein the N permanent magnet poles are formed by embedded magnets.

16. The motor of claim 9, wherein the commutation encoder is fixed to the rotor shaft outside of the motor and is of cylindrical configuration.

17. A multi-phase bipolar brushless D.C. motor, comprising:

a stator defining M phases, each phase having a plurality of windings connected in parallel and independently of the winding connection of the other phases;

a rotor shaft rotatably coupled to said stator and having N permanent magnet poles formed by embedded magnets which concentrate flux between opposing faces of like polarity;

a cylindrical commutation encoder at one end of the rotor shaft outside of the motor, comprising a circular plate and an annular ring defining at least one light shielding portion which functions as a non-sensing area, and at least one light detecting portion having opposite vertical edges which functions as a sensing area;

photo-sensors coupled operatively with the commutation encoder to provide two photo-transistors for each phase, each of the photo-transistors in the M phases being arranged, in turn, and one by one at intervals of predetermined shaft angle so as to produce a positive pulse when registered with the sensing area of the commutation encoder;

an electronic commutator including four power transistors connected across the windings of each phase of the stator, wherein two of the four power transistors of each phase being connected to one of the photo-transistors so that each phase is provided with two photo-transistors in order to perform the determination of the current direction according to the positive pulse of the photo-transistors, thereby flowing the alternating current through the windings to drive the motor; and

an electric power source connected in parallel to each phase of said electronic commutator;

wherein the width of the light detecting potion is determined by the following formula:

2π/ the number of poles x (the number of phases x K/the number of phases), wherein K is the commutation coefficient;

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the number of the light detecting portions is determined by the following formula:

(The number of poles)/2; and

the interval between each of the photo-transistors is determined by the following formula:

$2\pi/$ (the number of poles) x 1/(the number of phases);

whereby the motor is selected from a group consisting of 2-phase with 1-x-exciting, 3-phase with 2-y-exciting, 4-phase with 3-z-exciting . . .n-phase with (n-1-j)-exciting, where x, y, z and j are fractional commutation coefficients, thereby raising the efficiency, power, and speed of the motor.

19. The motor of claim 17, wherein the photo-sensor position of every other photo-sensor is the rotational sequence is moved rotationally to another pole of the same polarity at the same location in that pole as the original pole according to the formula: $4\pi/$(the number of poles), when the motor has insufficient area to properly position all of the photo-sensors.

20. The motor of claim 17, wherein the photo-sensors are arranged in a form of advanced commutation by a given angle in the direction adverse to the rotational direction of the commutation encoder from theoretical position to improve the performance of the motor, wherein the photo-sensor is coupled operatively with the commutation encoder in such a manner that, as occasion demands, the width between the light sensing portion can be adjusted in order to slightly change the width of the sensing area of the light detecting portion in order to modulate the exciting width of the windings and produce a bipolar partial square waveform, and wherein the photo-sensor includes a set of photo-transistors for use in a reverse rotation which set is provided in symmetric position separated from the two photo-transistors for use in forward rotation.